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17. ABSTRACT (MAX. 250 WORDS) The Air Force Academy instructional closed-circuit television system centers on the instructor. His teaching desk consists of three parts: a large flat surface with a turntable for rotating writing surfaces and visual materials; a slanted shelf for holding lecture notes with two 8-inch television monitors above it and a television control panel forward and below it; and a smaller flat surface for holding books and miscellaneous items.

Various types of visual materials can be placed on the turntable, allowing the instructor to show diagrams, charts, pictures, and texts without having them made into slides of transparencies. An overhead pickup camera is also used. During his televised presentation the instructor may show short concept films and portions of long films which would be impractical in a regular classroom situation.

Advantages of the instructor-centered television system are that the "break-even" point in cost is reduced to about 48 students, and that the instructor retains all of his traditional prerogatives and responsibilities.

Elements of instruction include: the selection, organization, and presentation of materials; and the direction of student activity to facilitate learning. Television, while an effective means of information presentation, is not the total means of instruction. The use of television with the classroom communication system allows the instructor to program his material to include questions and problems. Student responses may be either written or oral and may be electronically recorded for automatic data processing. Equipment information, answers to questions frequently asked about the system, and a specimen program are included.

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INSTRUCTION-CENTERED TELEVISION

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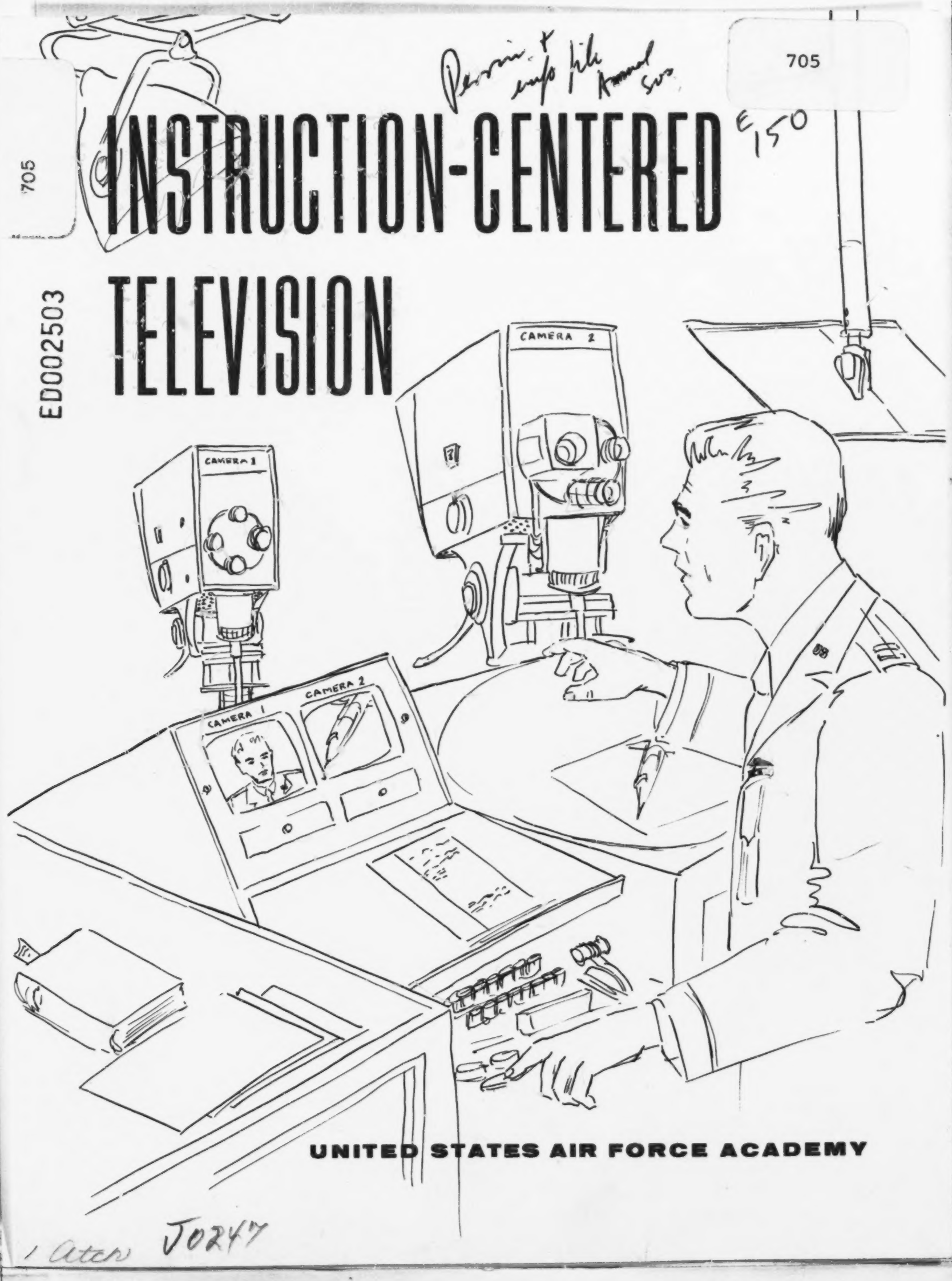

UNITED STATES AIR FORCE ACADEMY

J0247

INSTRUCTION-CENTERED TELEVISION

AT THE

UNITED STATES AIR FORCE ACADEMY

A Description and Preliminary Report

Prepared by

Captain John B. Haney, USAF
Chief, Television Division

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

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October 1962

Directorate of Instructional Research
United States Air Force Academy
Colorado

ED002503

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DEVELOPMENT OF THE CONCEPT

One of the key problems that the Academy faculty members assigned to the Directorate of Instructional Research faced in introducing television into the academic program was the design of a closed circuit television system that would be optimum from the standpoint of the instructor, the student, and the administration.

CRITERIA

An optimum instructional television system should meet several requirements:

1. It should allow the student to see a clear, life-size image of the instructor.

2. It should allow the instructor to take advantage of the characteristics of the medium of television and the resources of all types of visual supporting material.

3. It should allow the instructor to concentrate his preparation time on the lesson content and supporting materials, with a minimum of time on production rehearsals.

4. It should allow the instructor to maintain absolute control over the flow of information to the student.

5. When desired, it should allow the student to participate actively through responses to programed material presented by the television instructor, and it should allow the instructor to receive these responses as they are made by the students. Thus television presentation should relate to other component activities to comprise a total instructional system.

6. It should be of moderate initial and operating cost consistent with the desired quality, providing high quality pictures with minimum production crew.

COMPARISON OF CONVENTIONAL TELEVISION PRODUCTION WITH THE CRITERIA

The production arrangement used in virtually all of the existing instructional CCTV systems in colleges, universities, schools, and military installations allows some but not all of the above conditions to be fulfilled. The standard production arrangement was developed in American and BBC network television centers during the late thirties and early forties, and after World War II spread through commercial television stations to educational TV operations. Basically, it consists of a studio area containing the performer with his visual materials and set, hand-operated cameras, and a floor manager to relay signals from the control room area, containing the director and engineers. In some educational applications, personnel perform more than one function, as when a director does his own switching or a cameraman acts also as floor manager, but the usual minimum number of production people required for a TV presentation is seven. Thus, a substantial part of the cost of televised instruction occurs because of production personnel.

The conventional production arrangement does not allow the instructor to control the flow of information to his students, because it places between them a crew of television technicians. In particular, the television director determines what the students will see, and the fixed nature of the television script or run-down sheet compromises the instructor's regular freedom of choice and change, such as re-call of previously used visual material. Furthermore, the conventional television production arrangement requires that the instructor become involved in time-consuming production conferences and crew coordination rehearsals which are apart from the educational preparation of the lesson.

TOWARDS INSTRUCTION-CENTERED TELEVISION

The design of an optimum instructional closed circuit television system, therefore, required a complete rethinking of the process of televised instruction. Instead of starting with the conventional television production arrangement, the Academy instructional research staff started with the instructor himself, and then surveyed television production innovations and technological advances that could be used to assist him. One technological advance not available when the conventional television production arrangement was developed is the broadcast-quality vidicon camera, which is both stable and sensitive. The vidicon camera is considerably cheaper than the image orthicon camera, and since vidicon tubes do not readily burn in when trained on static objects, vidicon cameras can be used in fixed positions without operators. A production innovation is the use of such a vidicon camera with zoom lens in an overhead position, as devised by Mr. Rudy Bretz of UCLA, to pick up all kinds of visual materials. Another production innovation, used at the Los Angeles City College and the University of Utah, gives the camera switching operation to the instructor by means of a row of buttons on his desk. A combination of these elements with several original ideas produced the system described below.

THE USAF ACADEMY INSTRUCTIONAL CCTV SYSTEM

The center of the Academy instructional closed circuit television system is the instructor. In front of him is his teaching desk, consisting of three parts:

a. To his right, a large flat surface with a turntable for rotating writing surfaces and visual materials.

b. Directly in front of him, a slanted shelf for holding lecture notes, with two 8-inch television monitors above it and a television control panel forward and below it.

c. To his left, a smaller flat surface for holding books and miscellaneous

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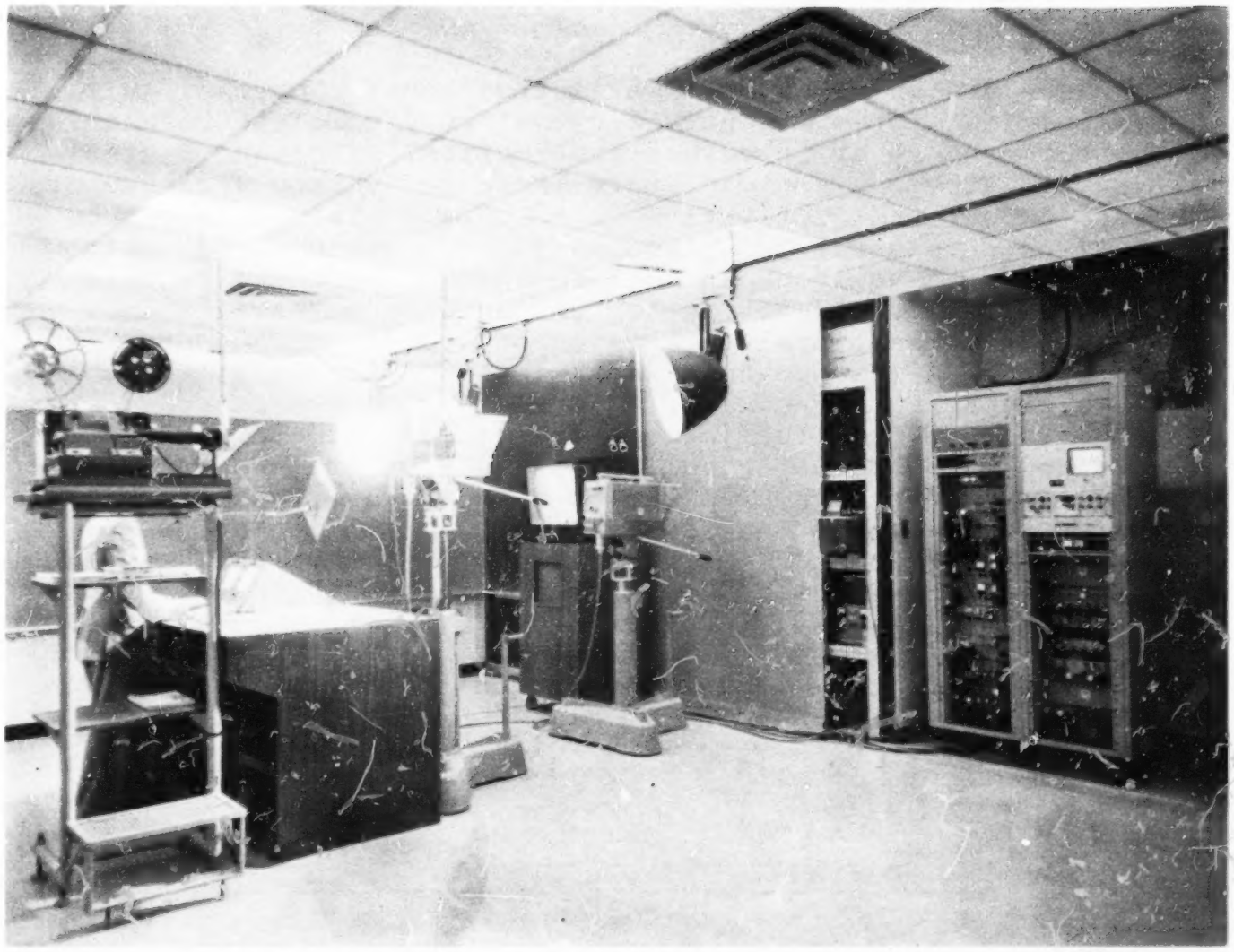
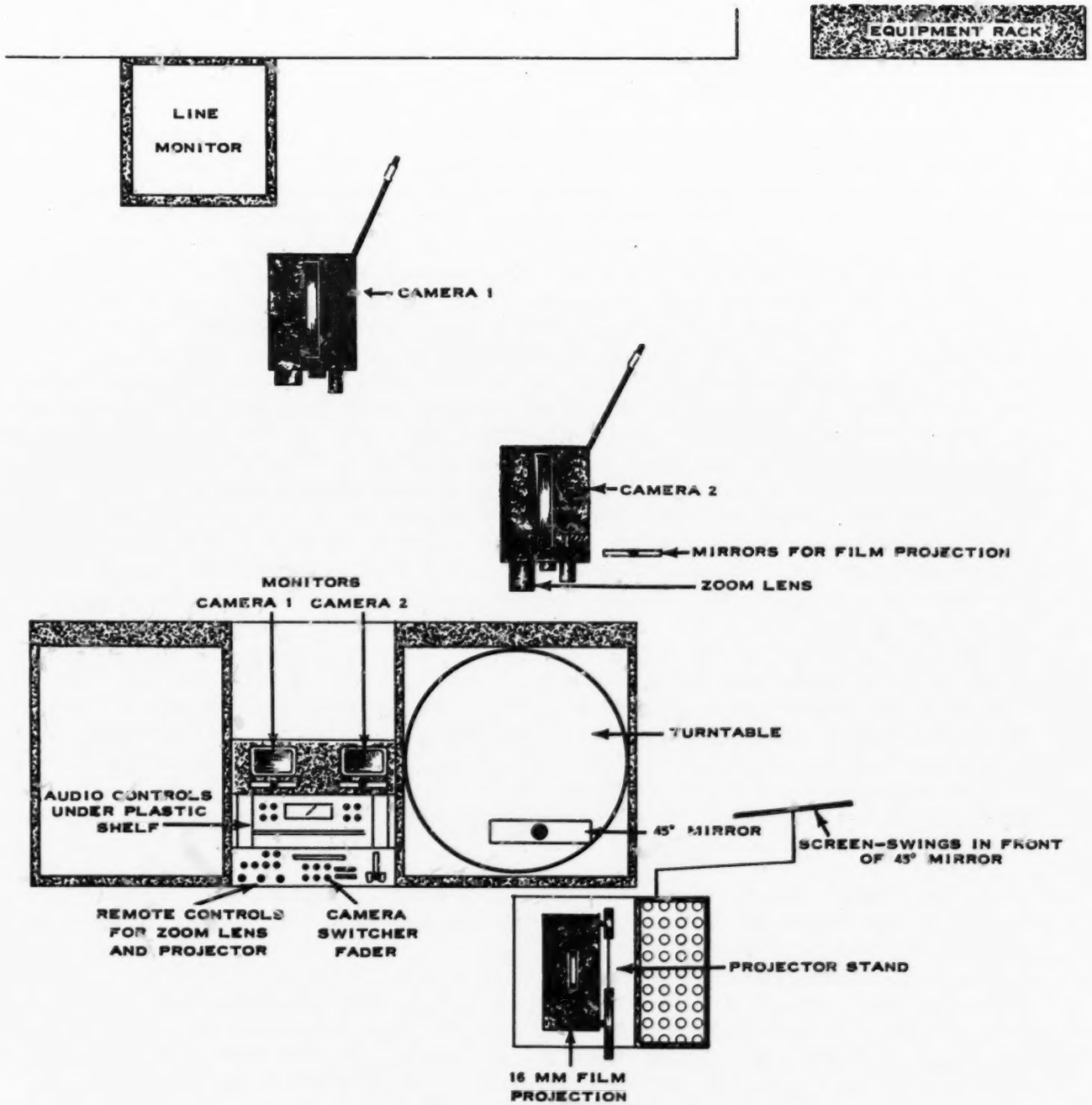


THE STUDIO, called the "originating classroom" is 20 x 28 feet in area. It is the same size as the the nine adjacent receiving classrooms. There is no control room.

PANORAMIC VIEW OF STUDIO DURING TELEVISED LESSON



FLOOR DIAGRAM OF TELEVISION PRODUCTION ARRANGEMENT

objects, and the student response indicator.

On the right side next to the instructor is a stand holding one 16-mm sound motion picture projector and one 35-mm or one 8-mm silent motion picture projector. In front and to the left of the stand (near the instructor's right shoulder) is a front-surfaced mirror at a 45° angle to the surface of the teaching desk. Approximately ten feet in front of the instructor (beyond the teaching desk) is a viewfinder vidicon camera (Camera One) mounted on a floor pedestal. This camera can pick up a medium close-up shot of the instructor behind the teaching desk. Camera One, by changing lenses, can get a close-up and an extreme close-up of the instructor as well, or a two-shot of the instructor and a guest, or a variety of shots of the instructor and an object on the left hand portion of the teaching desk. Directly in front of the turntable portion of the teaching desk is another viewfinder vidicon camera (Camera Two), mounted high on a floor pedestal, which picks up the image in the 45° over-head mirror above the turntable. By means of a remotely operated zoom lens, the camera can pick up an area on the turntable from 14 by 19 inches down to 5 by 6 1/2 inches. By holding an especially small object closer to the mirror, the pick-up size can be further reduced to 3 by 4 inches. By pulling a lever, the instructor can swing a screen in front of the mirror: the 16-mm motion picture projector then can project through one of two smaller mirrors located next to Camera Two, onto the screen, and so be picked up by Camera Two.

The image picked up by Camera One and Camera Two are constantly visible to the instructor on the two small monitors located above the slanted shelf in the center portion of the teaching desk. Two rows of three buttons each on the control panel in front of and below the slanted shelf allow the instructor to select any of the two camera inputs or black (dark, blank screen). A lever allows the instructor to fade from one row to the other. The control panel also contains the remote controls for the zoom lens on Camera Two and remote controls for the 16-mm motion picture projector. The instructor wears a lavalier microphone. The audio controls and volume indicator are on a remote audio console located underneath the slanted shelf. The shelf is made of transparent plastic so that the instructor can read the volume meter and reach under to adjust the audio controls when necessary.

ADVANTAGES OF INSTRUCTOR-CENTERED TELEVISION

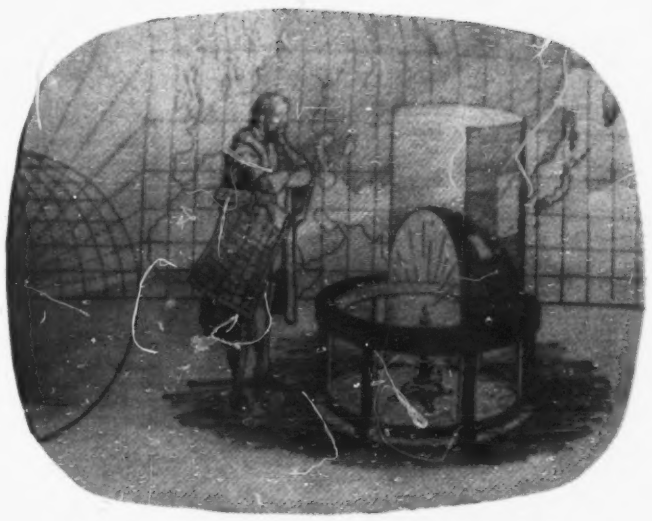
Cost - Using conventional production arrangements and techniques, several universities have found that the "break even" point at which closed circuit television becomes more economical for lecture presentations than small classrooms with separate instructors is around two hundred students. The cost factor largely limits the use of television to basic courses which have multiple sections meeting simultaneously. With an instructor-centered CCTV system, the "break even" point is reduced to around 48 students.

Faculty Acceptance and Use - The experience of many university television operations is that while a small proportion of faculty members are eager to televise their courses or present special televised lessons, and a somewhat larger proportion is willing to do so when persuaded or directed to do so, it is safe to state that the most prevalent faculty attitudes range from slightly negative or apathetic to overtly resistant. Some of these attitudes stem from an unfounded fear of technological replacement; others reflect sound professional concern about the nature of the televised instruction resulting from the placing of television personnel between the instructor and the viewing students. Even with a team approach of instructor and producer-director, with supporting graphic artists and script writers, the instructor often feels that he is compromising the freedom of choice and change that marks his regular teaching. With an instructor-controlled television system, the instructor retains all of his traditional prerogatives and responsibilities. There is no television middleman. Thus, the instructor can come to television on his own terms. Eventually, on the basis of faculty acceptance, it is hoped that appearing on television will be to teaching what publication is to research and writing.

THE INSTRUCTOR stands behind the teaching desk, and Camera One (the camera to the right in the above photo) picks up a medium close-up picture of him. An "off the line" photo of this picture is reproduced to the right of this column. Once set up for the instructor's height, the camera is not usually moved during the televised lesson. But when desired, this camera can be manually operated and a variety of lenses used to change the picture from a wide-angle view of the entire desk area to an extreme close-up of the instructor's face pronouncing words in foreign language instruction. This camera can also be dollied in to pick up large objects on the portion of the desk to the left of the instructor. The teaching area is lighted by two rear spotlights and by three front scoops.

THE SYSTEM IN OPERATION

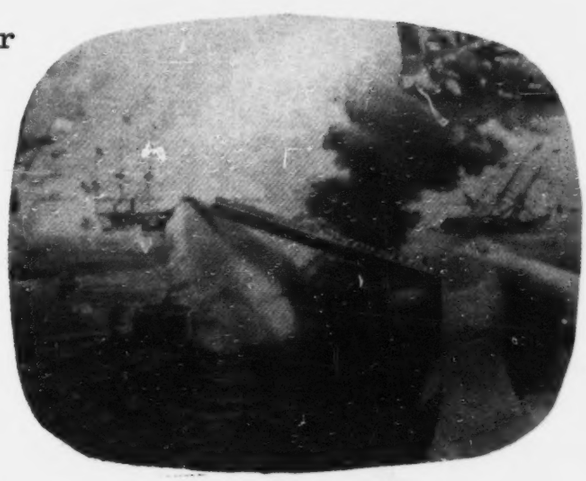
Camera One



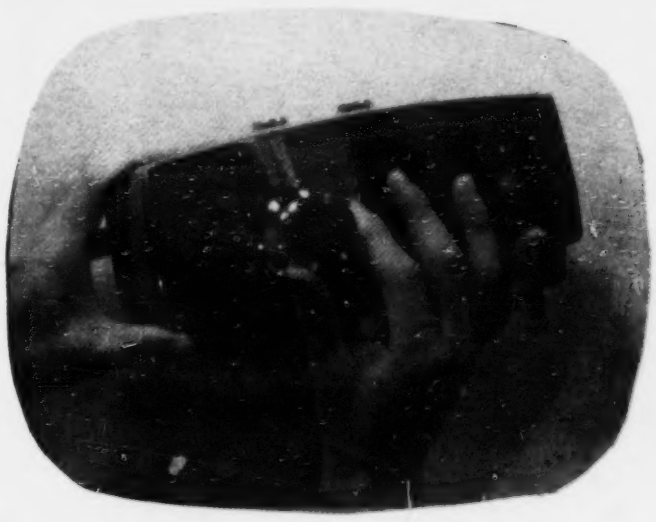
Camera Two

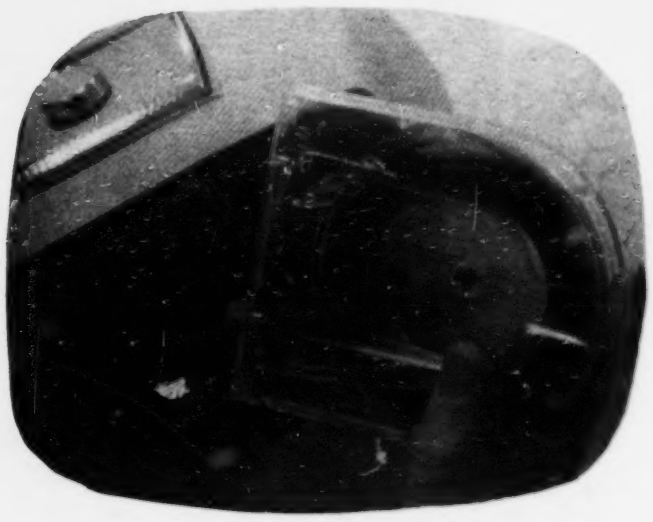
DURING THE televised lesson, the instructor can check the pictures from both cameras on the two small monitors in the center of the teaching desk. While looking at Camera One, he can glance slightly to the left to check the picture on the large line monitor. This monitor shows exactly what is being seen in the receiving classrooms. In this photo, Camera Two is picking up a line drawing of Gerhard Mercator making his map projection, which is on the the turntable of the teaching desk near the instructor's right hand. The instructor is able to switch from one camera to the other to change the picture on the line monitor. To the left of this column in an "off the line" photograph of the picture on Camera Two. In addition to these two pictures, the instructor can go to "black" (a blank screen).

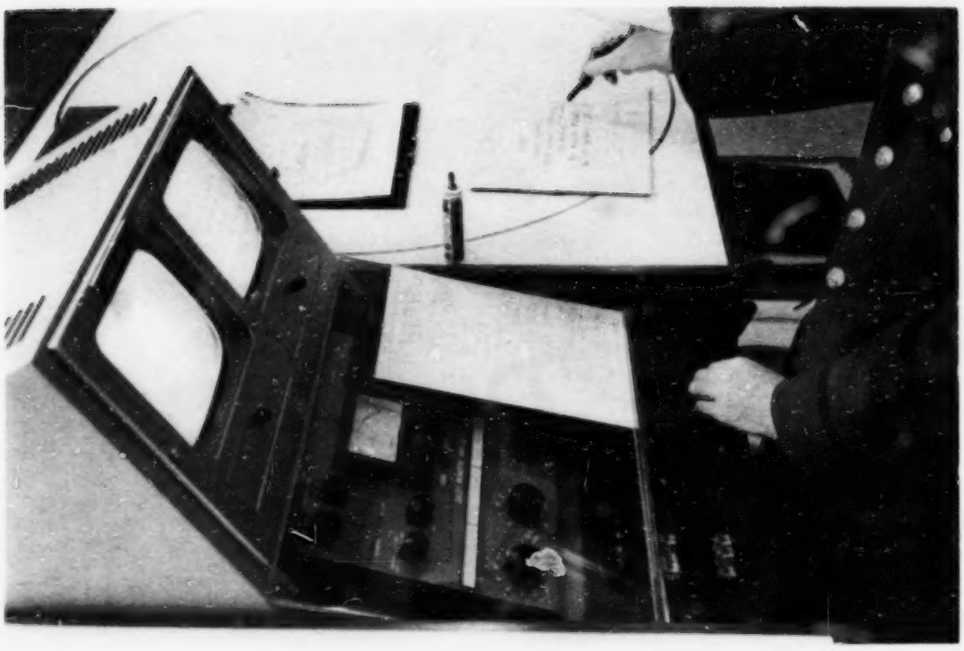
ALL KINDS of visual materials can be placed on the turntable under the 45° overhead mirror. The instructor can show diagrams, charts, pictures, and text from books and magazines without having them made into slides or transparencies, and without cutting them out. A zoom lens on Camera Two shoots through the overhead mirror to pick up an area on the turntable from 14 x 19 down to 5 x 6 1/2 inches. The instructor has remote control of the lens and can zoom in and out, always in focus. The instructor is able to point out specific things that he wants his students to see, as in the above photo, with the result as shown in the photo to the right. The slanted plastic shelf in the center of the teaching desk allows the instructor to look through and see the volume meter to set the audio level. After the level is set, the shelf holds the instructor's notes.



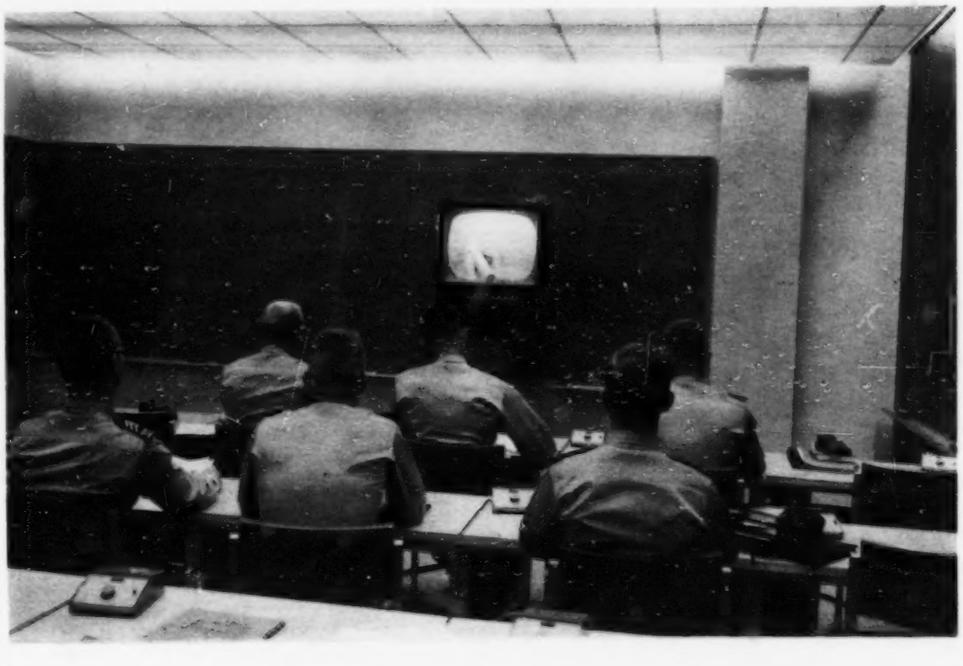
THE OVERHEAD pickup is not limited to flat visual material. Here the instructor demonstrates the use of the 8-mm cartridge motion picture projector. He can hold it in front of him for establishing shot, then place it under mirror and zoom in for details.

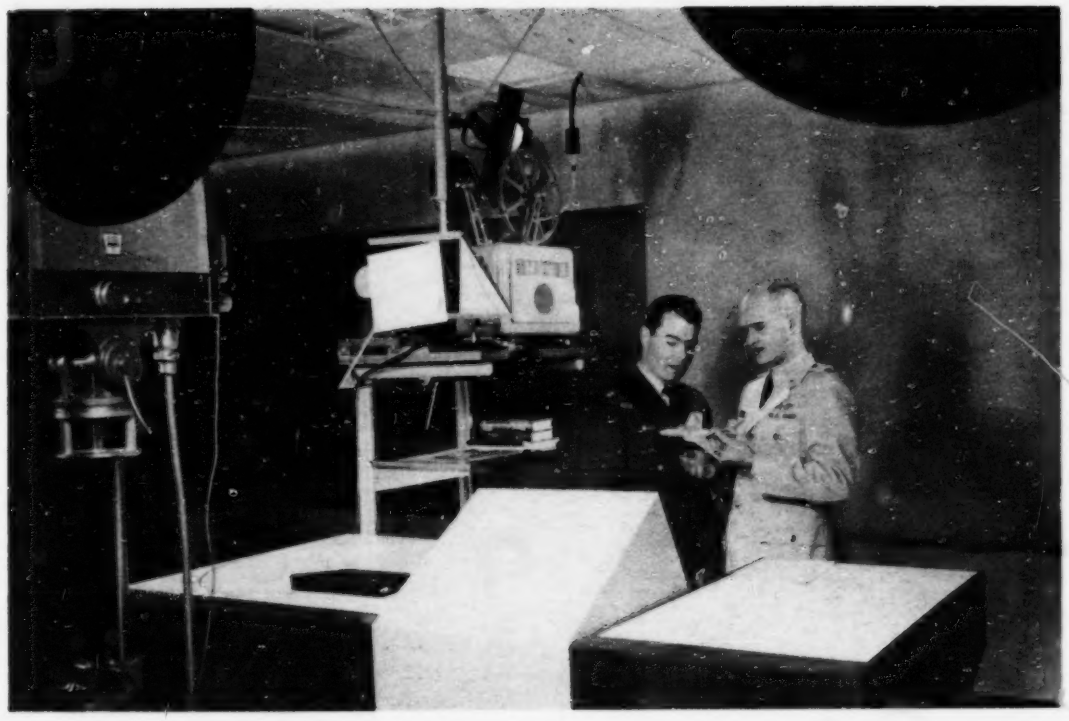




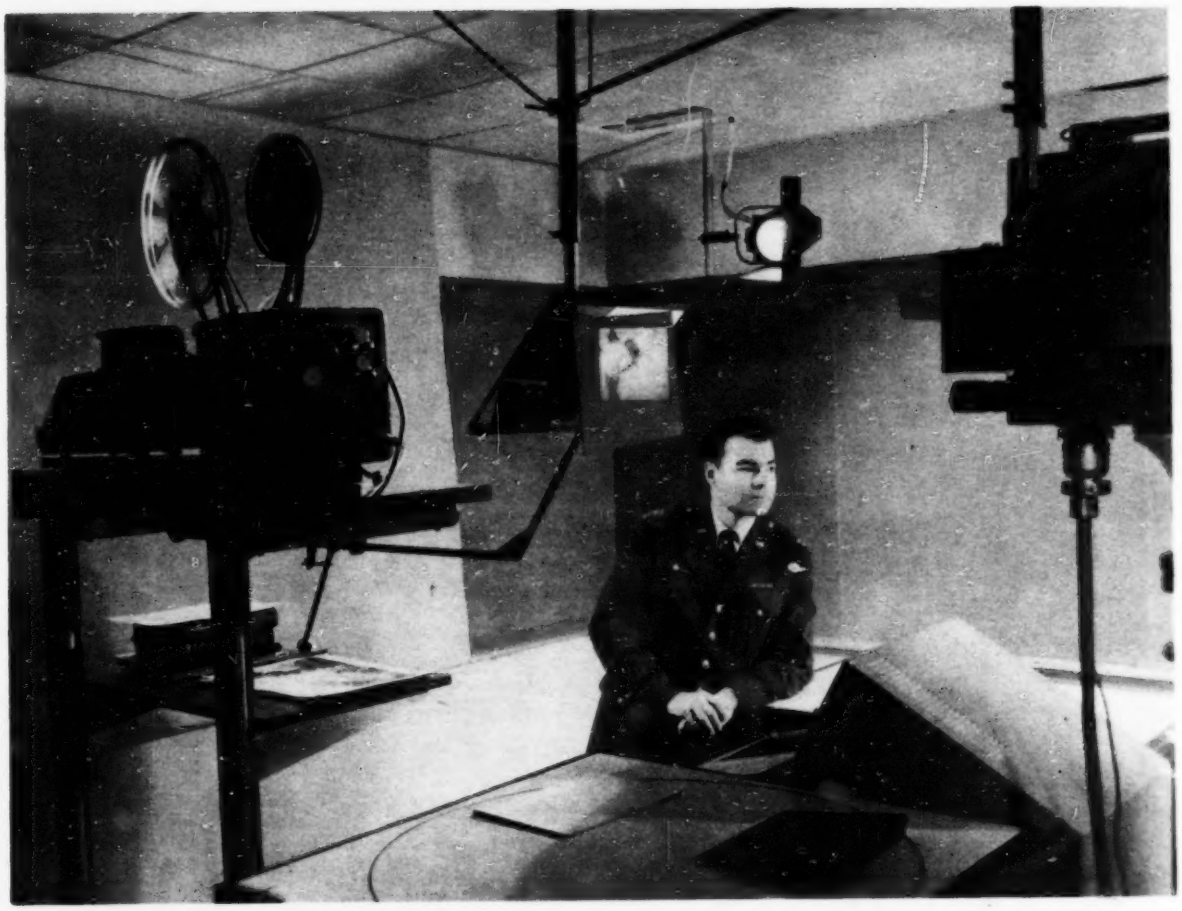


CHANGING THE picture on the line monitor is an easy task, for the instructor merely moves the fader lever back and forth to alternate views of himself and his visual material. The pad of blue paper is his "blackboard," and he can write on it in pencil or felt-tipped pen. BELOW: a receiving classroom.





ALTHOUGH DESIGNED to pick up a medium close-up of a single instructor, the same lens on Camera One can pick up a two-shot of instructor and guest. Because there is no operator on Camera One, the two stand elbow to elbow and check the monitors for pictorial composition. The instructor may turn toward the guest to emphasize him in the picture. The old television adage "if ya ain't touchin', ya ain't in" was never more true. The RF-84F model aircraft which the pilot is explaining can be held under the 45° front-surfaced mirror for a magnified view.



TO SHOW a film, the instructor (1) fades to black, (2) swings screen into position in front of the 45° mirror, (3) turns off the front scoops, (4) flips a lens on Camera Two, and (5) operates the remote controls for projector sound, run, and show. The motion picture image is projected onto a small front-surfaced mirror suspended from the ceiling next to Camera Two, and is reflected back onto the screen, there to be picked up by Camera Two. These four elements are aligned so as to virtually eliminate the keystone effect on the transmitted picture.

During his televised presentation, the instructor may show short concept films and portions of long films which he might not make the effort to do in his regular classroom instruction. In the Aero course, for example, the instructor uses the MIT series of four-minute films on fluid mechanics, and clips such as a two-minute segment of a film showing tornadoes.

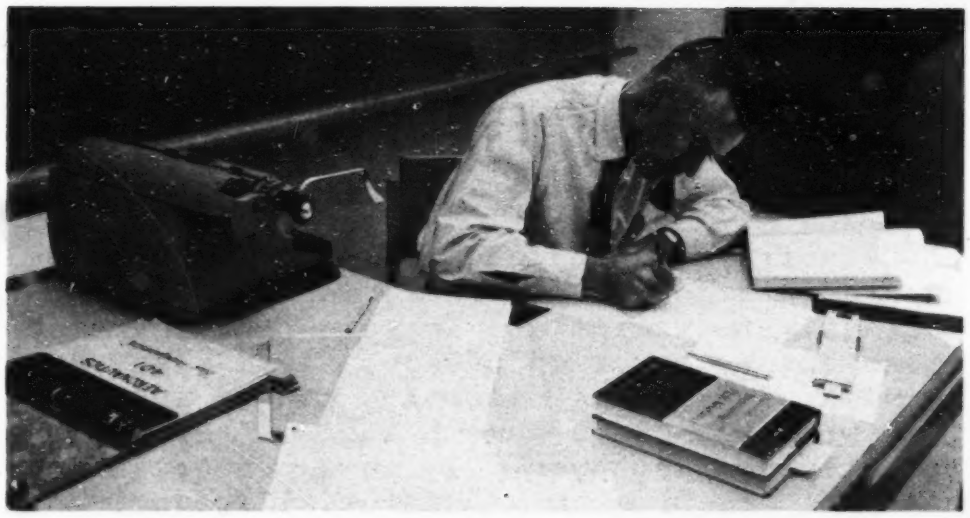
GROUP PROGRAMED LEARNING THROUGH THE TELEVISION AND CLASSROOM COMMUNICATION SYSTEMS

The elements of instruction include the selection, organization, and presentation of material, and the direction of student activity to facilitate learning. Television is an effective means of information presentation. Just as some of the principles of programed learning can be applied to improve textbook writing, these same principles can be incorporated into televised lectures. In this connection, the instructor needs (a) to program his material to include questions and problems, (b) receive student responses, and (c) adjust his presentation accordingly.

The classroom communication system, used in conjunction with the CCTV system, allows the instructor to do this. The instructor devises a written program covering the content of the lesson, containing multiple choice questions or problems to work. Each student receives a copy of this program before the television class period. During the televised lecture, the instructor directs the students to answer a question and signal their choice, or work a problem and signal when finished. In each case, the student writes his response in a space provided in the program and then uncovers the correct answer for self-correction or reinforcement. The rate of response and percentage of correct responses, displayed on the instructor's console from the 48 student response stations (16 in each of 3 classrooms), tell the instructor about how well the students understand and are able to apply the concept under consideration.

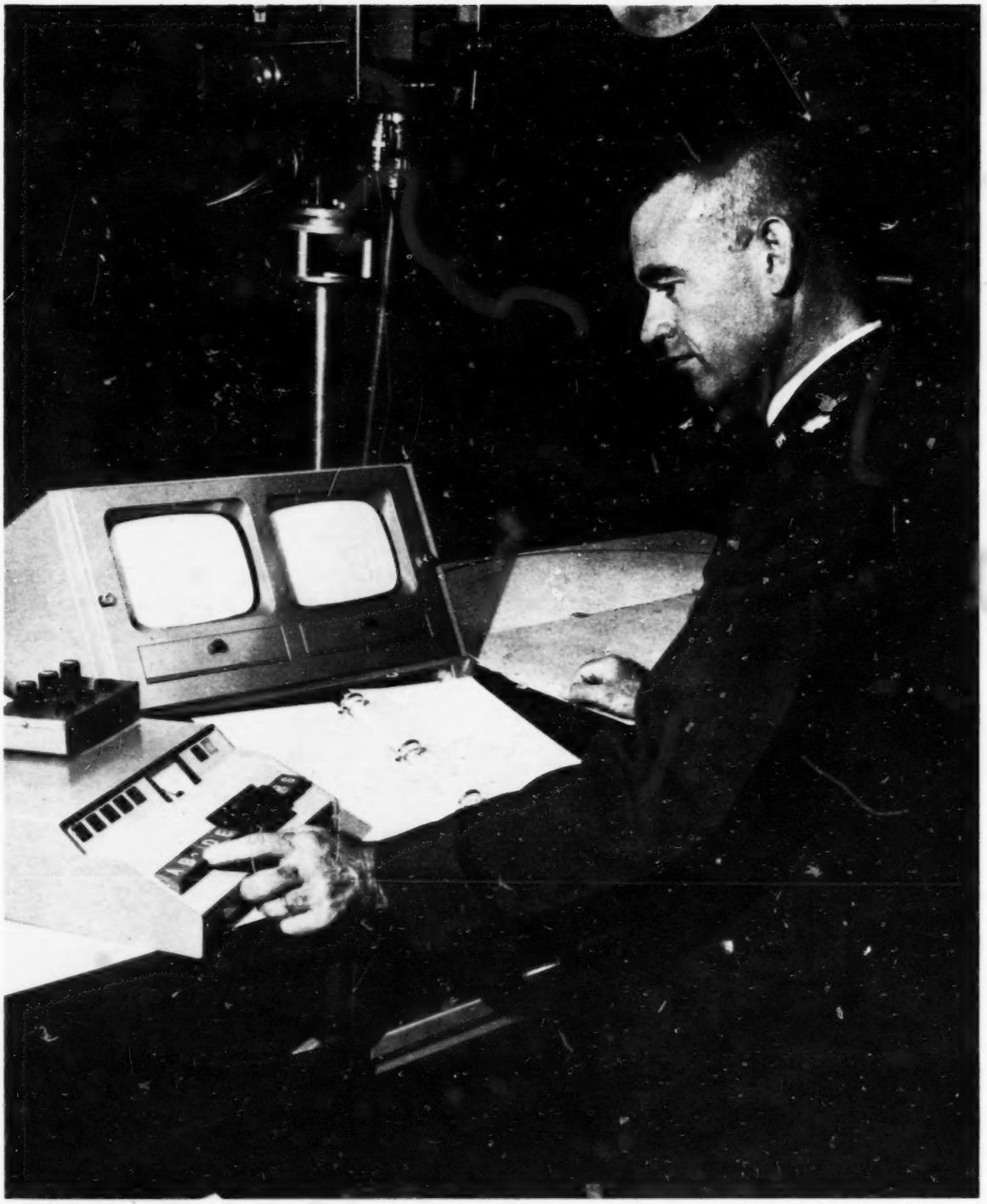
Thus, television is used as the major means of information presentation but is not the total means of instruction. The instructor becomes the center of an instructional system. This flexible combination of television and the classroom communication system also provides for oral rather than written programing and electronic recording of student responses for automatic data processing.

A specimen program used in Aeronautics 401 is included as an appendix to this report. It is not a complete program in itself, for it requires the television presentation for explanation, illustration, and direction.



AN INSTRUCTOR prepares his lesson at his desk, by researching material and writing notes, and in addition, marking material for visual presentation. The instructor above also writes the program for the Aeronautics course, which he will use in connection with the classroom communication system.

IN THE receiving classroom, cadets work a problem based on the televised diagram, and signal their answers to the instructor in the television studio.



AS PROGRAMED questions are asked, the instructor sets the Teletest console to the correct answer, and watches as the percentage of correct responses come in from the individual student stations. He can then clarify the point or go on to the next. The instructor can also determine when all of the students have responded.

EQUIPMENT INFORMATION ON THE ACADEMY CCTV SYSTEM

In the originating classroom:

2	Sarkes-Tarzian model 880 broadcast-quality viewfinder vidicon cameras, mounted on Sarkes-Tarzian telescoping pedestals and tracking dollies, with related camera controls
2	sets of Wollensak 16-mm mount lenses
1	Mark IV Zoomar lens with remote controls
1	Sarkes-Tarzian synchronizing generator with EIA sync and power supply
1	Master monitor unit, consisting of a Techtronics 5" waveform monitor and 8" Conrac picture monitor with pulse-cross, and Tel-Instrument bar-dot generator
2	Sarkes-Tarzian video limiting controls
1	Sarkes-Tarzian custom switching unit and console
2	Conrac 8" monitors
1	Collins remote audio amplifier and audio distribution amplifier
4	Sarkes-Tarzian video distribution amplifiers
2	Electro-voice lavalier microphones
1	Bell and Howell 16-mm sound motion picture (JAN) projector with 5" lens
1	Bell and Howell 8-mm silent motion picture projector
1	Bell and Howell 35-mm slide projector with 14" modified lens
2	Kliegl 500 watt spotlights
4	Kliegl 750 watt scoops
1	Teaching desk and projector stand built by Audio-Visual Services at the United States Air Force Academy

In each of the 10 receiving classrooms:

24" Conrac video monitor

Bogen-Presto 10-watt audio amplifier

8" University loudspeaker

Cabinet made by Sarkes-Tarzian, veneer finishing by Academy Audio-Visual Services

The total cost for engineering, equipment and installation of the above items was $35,000.

The 4-console, 48 station classroom communication system (trade name: Teletest) is manufactured by Corrigan Communications, Inc., Fullerton, California.

QUESTIONS FREQUENTLY ASKED ABOUT THE ACADEMY CCTV SYSTEM

How difficult is it for instructors to learn how to operate the TV controls while teaching?

It seems more difficult to explain than to do. The instructor does not have to go through a one-man band routine in order to present a lesson. There are 59% fewer controls to operate on the TV console than there are on an automatic-shift car. In about thirty minutes of practice, the instructor can learn the feel of the essential controls (the two rows of three input buttons each, the fader lever, and the zoom lens in-out control) so that he need not look down while telecasting. After two or three sessions, the instructor has only to think of what he wants the students to see, and his hands reflexively operate the controls to bring this about.

Why teach many small sections in individual classrooms instead of one large group in a lecture hall?

First of all, the Academy does not have enough large lecture halls to accommodate over six groups at one time (one 3,000-man theatre, one 1,000-man lecture hall, and four 400-man lecture halls.) There is an average of 22 multi-section courses meeting each hour of the day. Second, television can allow the instructor to exploit the characteristics of the medium (attention, selection, magnification, and flexibility) and illusions of the medium (intimacy, immediacy, and synthesis) to enhance his presentation.

Will TV replace the classroom teacher?

This often-heard question can best be answered in the conceptual framework of a model of the instructional process. Such a model can be based on a systematic analysis of (1) the operationalized objectives of instruction, (2) the functions required to attain these objectives, and (3) the alternate means of carrying out these functions.

An important function in the instructional process is the presentation of information. This may be done to groups

simultaneously through live lectures, films, and television, or to individual students at any time through books, periodicals, handouts, and now 8-mm film. In this context, television may be regarded as an extremely effective means of both presenting and distributing information. However, there are other functions of instruction, such as accommodating student expression, creativity, and questions, which can be handled by a teacher with a small group of students or a single student. Auto-instruction programs can handle other functions at an individual's own level and pace. Thus, television helps education to realign its personnel and material resources for increased efficiency and effectiveness.

From an educational standpoint, a greater problem than producing instructional television presentations is planning other learning activities (overt and intellectual responses, discussion, creative projects, reading, writing, and so forth) to complete an instructional system. In short, classroom teachers will be able to concentrate time and effort on functions they, as persons, uniquely are able to accomplish.

> Will "instruction-centered, instructor-controlled" television replace conventional television production patterns.

The self-directed concept of television provides an alternate method of television production where applicable; that is, in virtually 100% of briefings (to use the military term) and up to 90% of direct instruction. Educational television is a broader term that covers a wide range of cultural and informational shows, discussions, and documentary programs which are not suitable for self-direction. We feel that instruction-centered television is the ideal means to introduce instructional television into a school, college or university, and that existing instructional television operations might well set up one studio in this pattern for experimentation and comparison.

Because of the modular nature and minimal space requirements of the instructor-centered system described in this report, several of them can be decentralized throughout a campus. The campus or school system television center can continue to produce general educational programs and high-quality instructional tapes for inter-institutional and national exchange. Even in this latter use, however,

the major segment of a recorded television lesson can be produced under the instructor's control, and then electronically edited for adding the opening and close, special inserts, and reaccomplished sections.

How can you get a smooth professional production with an instructor-controlled system?

We don't try. The comparison is not to the "Show of the Week" but to classroom teaching. We establish certain conventions, such as reaching over to pick up a book or magazine, opening it while on camera, placing it on the turntable and switching to the overhead pick-up. The student may then see the camera zoom in to the desired framing. The student can accept these illusion-shattering conventions, just as television audiences have come to accept the visible lavalier microphone on commercial TV performers, although in the early days of TV a microphone was never shown.

What features of the Academy CCTV system do the instructors who use it like best--and least?

The instructors like the naturalness of the teaching situation, the degree of freedom to show all kinds of visual materials without having to have slides and transparencies specially made, and the ability to recall visuals as desired. The instructors dislike a lack of "eyeball-to-eyeball" contact with students, and the lack of a video tape recorder. At present, an instructor must present each lesson several times.

Where can one find additional information about the "instruction centered, instructor-controlled" concept of television.

To answer this question, we suggest that you read an article in the March-April 1961 NAEB Journal by Rudy Bretz, entitled "Self-Directed Television," and reports of KUED at the University of Utah.

For what courses does the Air Force Academy use the CCTV system?

Starting with the Fall semester of 1962, which began on 20 August 1962, the CCTV system is used to present two courses: Aeronautical Engineering 401 for one period every other day to three sections of 16 cadets each, in which the Teletest system is used in connection with the programed lecture; and Academic Skills 100 for three periods every day to nine sections of 16 cadets each (the entire freshman class). A new lesson is presented every other day, meaning that each Academic Skills session is repeated six times. The Aero course is taught by Major Arthur R. Steiger, Associate Professor of Aeronautics and Director of Instructional Research. The Academic Skills course is taught by a team of instructors: Management of Time and Study Reading by Captain John C. M. des Islets, Chief of the Academic Skills Division; The Process of Writing Themes, Listening and Note Taking, Preparing for Discussion, Using the Library, and Memory Training by Captain John B. Haney; How to Study for Math, Chemistry, Physics, and Physiology by eight instructors from the represented departments; and the Psychology of Learning by Major Franklin C. Butler, Jr., Chief of the Auto-Instructional Division. An accounting and evaluation of the CCTV operation is in progress.

How large is the Television Division that runs this operation?

One officer. There is one manpower position for an engineering supervisor, which is presently unfilled. A maintenance contract covers daily camera set-ups, preventive maintenance, and trouble shooting. This contract is part of the general electronics maintenance contract for the Academy, and two persons are located in the Academic building for this service. As an instructional activity, the television system along with the language laboratories gets priority for their attention.

Does the instructor get any help at all in his preparation and presentations?

In preparing the content of the lesson, the instructor receives the advice from his colleagues in his academic department. The prescribed courses in the Academy curric-

ulum are staff prepared, with defined objectives and major areas of content (method of teaching is left up to the individual instructor). The academic instructor is used to receiving research findings and background material from other members of the course instructional staff who have specialized in particular areas and he, in return, provides other similar information in areas of his own specialization. In some TV courses, a variety of instructors share the television presentations.

The Chief of the Television Division not only checks out instructors on the use of the TV system, but goes over the material of the lessons to suggest methods of presentation, visualization, organization, and support. This is an important part of the work of a true television producer-director that is often neglected when a director has to "wing" a program owing to hasty prior consultation with the instructor. The Academy television chief has had considerable experience in directing broadcast and closed circuit television programs and holds advanced degrees in broadcasting, but in addition he has taught full-time in the Department of English for two years and still teaches on a part-time basis. Thus, television instructors view the television advice and critique as coming from a teaching colleague as much as a television specialist.

The instructor has assistance from Audio-Visual Services in making titles, illustrative sketches, models, and films. The Audio-Visual department has set up a special sub-section located in the midst of faculty offices where the television instructor can produce such materials with the illustrator on duty without a "work order" form.

During the televised lesson, the instructor may be assisted by another instructor or guest to be interviewed. An assistant can help in handing bulky materials to the instructor, flipping lenses on Camera Two for film pick-up, panning or tilting Camera One for special shots, etc. One such person is helpful; two really get in the way and lead to the coordination problem of conventional TV production.

APPENDIX: Specimen Program

Number of incorrect responses for Part A: _____

AERO 401 E
Lesson 2
Part A

1. In the atmosphere, pressure (increases, decreases, stays the same) as altitude increases; the sign of the differential dp/dh, change of pressure with change in altitude is (plus, minus, zero).

decreases, minus

2. The lapse rate, dT/dh, change of temperature with altitude, is (constant, zero) within the troposphere, the atmospheric layer nearest the earth's surface.

constant

3. The standard sea level temperature is ____°F or _____°R.

59, 519

4. What is the sum of the forces acting on a fluid element at rest?

zero

5. What forces must we consider to be acting on the element at rest? _____ and _____

pressure, gravity

6. What is the volume of the fluid element? _____

A dz

7. What is the weight of the fluid element? _____

$\gamma A\, dz$ or $\rho g\, dz$

8. Sum the forces acting on the fluid element: _____ _____

$pA - (p + dp)A - A\, dz = 0$

9. The sign of the term, dp/dz, is (plus, minus, zero). _____

minus

10. Integrate this expression assuming a constant specific weight:

$$\int dp = -\int \gamma dz$$

$$p_2 - p_1 = -\gamma(z_2 - z_1)$$

AERO 401 E
Lesson 2
Part A

11. What are the units of pressure head, p/γ? _____

ft.

12. What is the height of a mercury column equivalent to the standard pressure at this altitude, 1627 psf? _____

1.92 ft or 23.04 in

13. For the flow illustrated in the manometer problem:

p_A is (greater than, equal to, less than) p_B
p_B is (greater than, equal to, less than) p_C
p_C is (greater than, equal to, less than) p_D
p_D is (greater than, equal to, less than) p_E

$p_A < p_B : p_B = p_C : p_C > p_D : p_D > p_E$

14. How may the sensitivity of the manometer reading be increased--i.e., increase the scalar value of h_M? _____ or _____

Reduce s.g. of manometer fluid

incline manometer tube

15. Write the relationships for the hydrostatic equation, polytropic process, and the equation of state. _____; _____; _____.

$dp = -\gamma dz$;
$p/\rho^n = \text{Const.}$; $p = \rho RT$

16. Does the equation of state apply to all fluids? (Yes, No). What, if any, is the restriction on its use? _____

No; applies to perfect gases only

17. What is the value of n in the relationship for a polytropic process for the isothermal process and an adiabatic process: _____ and _____.

1.0 and 1.4

18. Can we integrate the expression, $\int_1^2 dp = -\int_1^2 \gamma dz$, as it applies to the atmosphere?

No

AERO 401 E
Lesson 2
Part A

19. Substitute for ρ in the above integral a relation including p and g, R, and T. _____

$$\rho = \frac{g \cdot p}{RT}$$

20. Integrate the expression: $\int_1^2 \frac{dp}{p} = -\frac{g}{RT} \int_1^2 dz$

$$\ln \frac{p_2}{p_1} = -\frac{g}{RT} (z_2 - z_1)$$

21. From the expression $p_2/p_1 = e^{-g/RT(z_2 - z_1)}$, substitute and obtain a similar expression for ρ_2/ρ_1.

$$p_2/p_1 = \rho_2/\rho_1 = e^{-g/RT(z_2 - z_1)}$$

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